MUSKWA PROJECT

Draft Problem Analysis/Working Plan

Submitted October, 1982

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Summary

This report outlines the goals and objectives of the wildlife program with special emphasis on mountain sheep, elk, caribou and moose in the Muskwa area (14,000 sq. km.) of northeast British Columbia. It describes the study area and the population status of those species at present, in comparison to the past and their future potential. It discusses the range enhancement that has been undertaken to augment those populations. The report looks at supply and demand for those species. Major declines in numbers of the 4 large mammal species from past levels are documented and excessively high mortality of animals prior to breeding age is identified as a major cause of the declines and as a block to recovery. Much of this mortality is described as being caused by wolves which occur in the area at a very high density. A program of wolf control is proposed to reduce the mortality of young sheep, elk, caribou and moose to allow those populations to increase and take advantage of the range enhancement that has been done. Monitoring and review are an integral part of the program.

Addendum

Further information has accrued since this document was prepared. In particular, due to continued declines, the original population estimates would now be less. Indeed, the elk decline increased markedly to 9% annually (Elliott, J.P. 1983. North East British Columbia 1982-1983 Elk Enhancement Program. Unpublished Report. B.C. Fish and Wildlife Branch, Victoria).

Also, the wolf density is now estimated at 1 per 13 square miles (Elliott, op. cit.).

PREFACE

This report was prepared as a working document for use by Ministry of Environment staff. As such it was reviewed and approval given to proceed with option 1. In the interim suggestions for improvement were made and revisions are underway. A final document is slated for publication.

Because of the considerable interest in the project we are making this draft available to the public as background information. Readers are reminded that while useful as a planning/working document it is not in the polished form normal for Branch publications.

Fish and Wildlife Branch
Ministry of Environment
British Columbia

January, 1984

MUSKWA PROJECT

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MUSKWA PROJECT

1. Wildlife Management Goals and Objectives.

The Muskwa Project must be considered within the context of zonal and provincial management objectives and priorities. This allows definition of the relative importance of the Muskwa subunit from a management and budgetting perspective.

Table 1 presents the provincial concept (Fish and Wildlife Branch, 1979) of species priority. These priorities were derived from the goals of wildlife management, an appreciation of public demand and the need for public safety. The goals of wildlife management for the province are:

1) Maintain the diversity and self sustaining ability of species representative of the major biophysical zones of the province, and

2) Ensure that within constraints of land capability and biological limits of each species, wildlife is available in sufficient abundance to meet the social, recreational, ecological and economic needs of society.

Table 1. Provincial Priorities by Species.

Species	Priority
endangered or threatened	1
moose, elk, deer, caribou	2
mountain sheep, mountain goat, bears	3
raptors, wolf, cougar	4
waterfowl, furbearers, upland game birds	5
non-game birds, and mammals, reptiles, amphibians	6

Table 2 presents the proposed provincial objectives (Fish and Wildlife Branch, 1979) for the first three provincial priorities.

Table 2. Provincial Objectives for Priority 1, 2 and 3 Species.

Species	Objective
endangered or threatened	enhance so they are no longer endangered
moose	300,000 animals, harvest of 30,000
deer	475,000 animals, harvest of 60,000
elk	22,000 animals, harvest of 3,000
caribou	20,000 animals, harvest of 1,000
mountain sheep	16,000 animals, harvest of 450
mountain goat	50,000 animals, harvest of 1,500
grizzly bear	5,000 animals, harvest of 250
black bear	not stated specifically

(As shall be seen, there are some inconsistencies between these objectives and those of the zone which result from the accrual of new information since the provincial objectives were defined over four years ago).

The north east zone (Figure 1), as the name implies, lies in the north east corner of British Columbia. It comprises approximately 40% of the Omineca Peace wildlife administrative region which in turn includes nearly one-third of the land area of the province.

The large size and ecological diversity of this zone has made it desirable to subdivide to smaller units suitable for project planning. These eleven units are shown in Figure 2. Boundaries were chosen on the basis of wildlife use, public use, existing administrative boundaries, and major land features. These boundaries may be refined in the future. Table 3 gives the approximate land areas of these units.

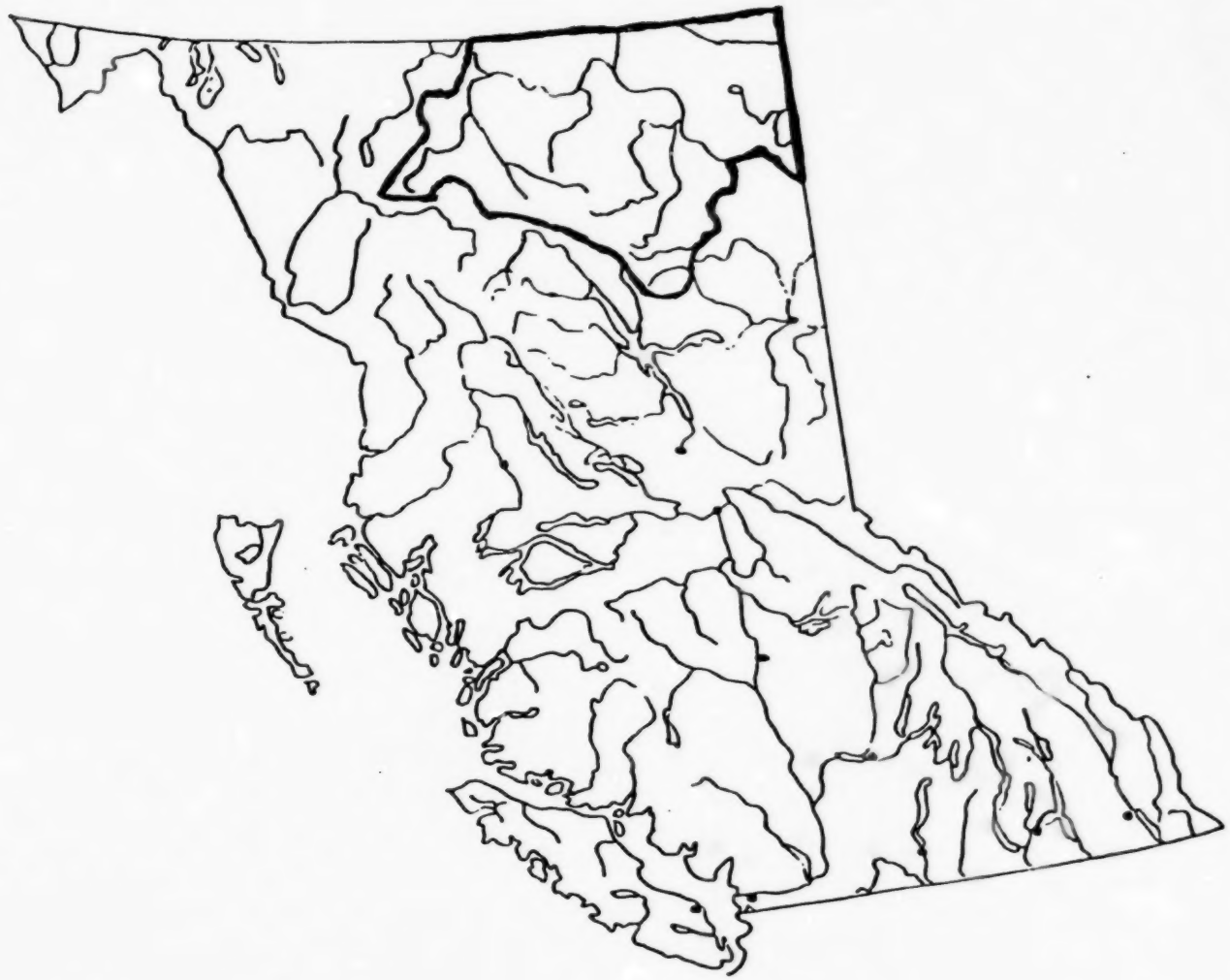


Figure 1. North East Zone.

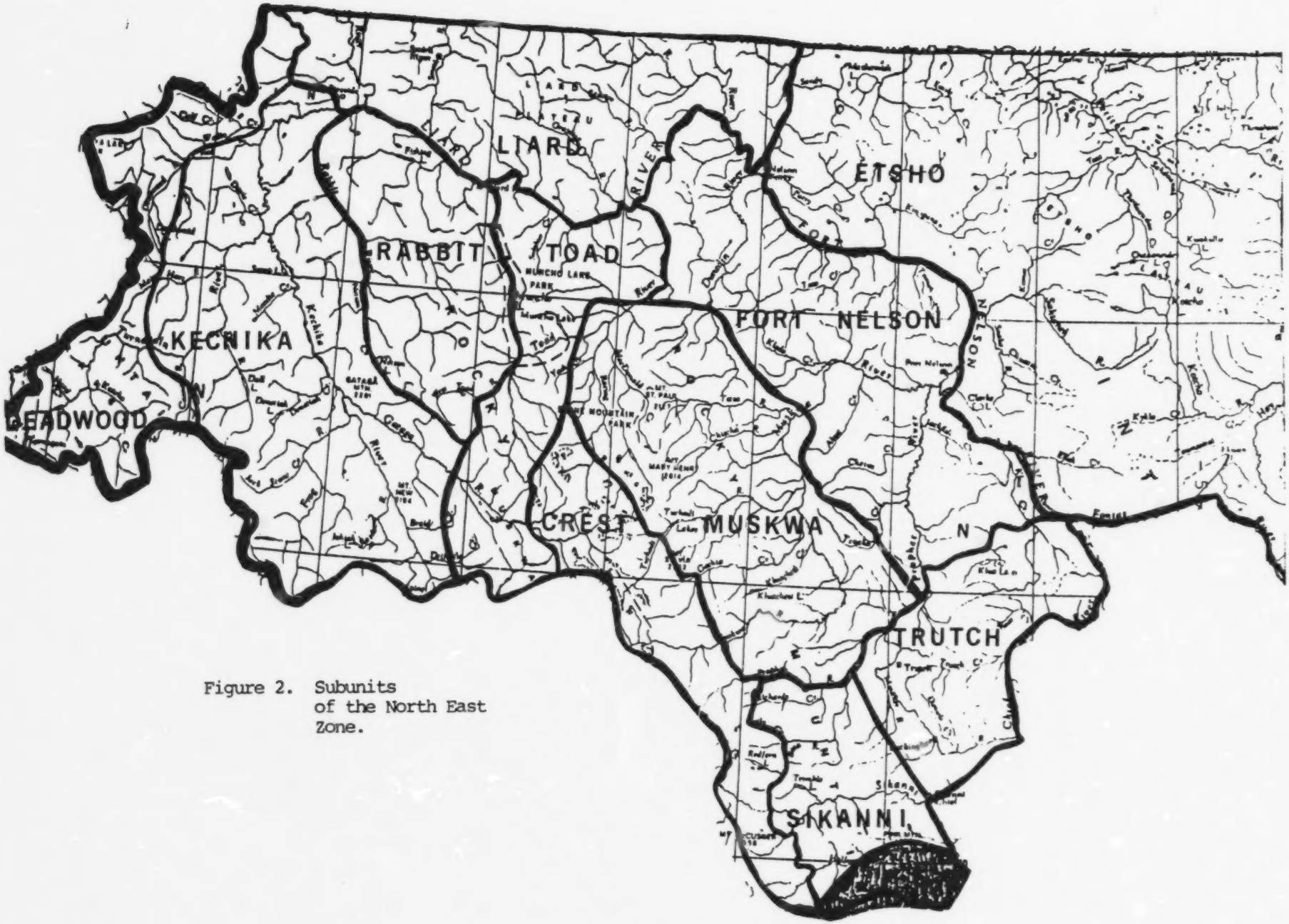


Figure 2. Subunits of the North East Zone.

Table 3. Subunits of the Northeast Zone

Subunit	Size (sq. km.)
Deadwood	7,000
Kechika	15,000
Liard	12,500
Rabbit	8,000
Toad	8,000
Crest	6,000
Muskwa	14,000
Fort Nelson	14,500
Etsho	39,000
Trutch	7,000
Sikanni	6,500
	137,500

Zonal species priorities (Table 4) have been defined, paralleling the provincial scheme.

Table 4. Northeast Zone Wildlife Species Priorities

Priority	
1	elk, mountain sheep, moose
2	caribou, mountain goat, grizzly bear
3	furbearers
4	endangered and threatened
5	deer, wolf, upland game birds, black bears, waterfowl, raptors
6	non-game birds and mammals, reptiles, amphibians

These priorities were defined on the basis of numerical abundance, potential for increase through management, and perception of public interest/demand. It can be seen that elk, mountain sheep, and moose are given the highest rating. Elk have a high demand by the public and a tremendous potential for expansion in this zone. Mountain sheep have the highest demand from the trophy standpoint and the northeast zone is the major mountain sheep area in the province. Moose is the most abundant ungulate in the zone, provides much the largest component of the ungulate biomass, and would still hold this key status subsequent to overall ungulate enhancement. The only negative associated with moose, is a feeling provincially that the "public" in general prefers southern over northern moose in order to reduce travel time. The full value of the zonal moose then is not realized until southern moose are oversubscribed, a situation which may already exist but is not reflected by a shift in demand to northern moose due to the present poor status of these populations.

Table 5 outlines the present population sizes for the zonal first priority species plus caribou. Caribou are included

in this table as they are ranked one level higher in the provincial priorities (Table 1).

Table 5. Present Population Estimates for Elk, Mountain Sheep, Moose, and Caribou in the Northeast Zone.

Subunit	Elk	Mt. Sheep	Moose	Caribou
Deadwood	-	300	2,000	500
Kechika	50	2,000	10,000	150
Liard	50	50	4,000	300
Rabbit	-	300	3,000	150
Toad	50	500	2,000	250
Crest	-	200	1,000	100
Muskwa	4,000	3,000	12,000	500
Fort Nelson	50	50	3,000	75
Etsho	-	-	4,000	75
Trutch	50	50	3,000	-
Sikanni	300	750	6,000	450
	4,550	7,200	50,000	2,650

Table 6 provides the zonal objectives for these same species. A comparison of this information to that of Table 2 shows that the zone can supply 113% of the province's elk objective, 112%

of that for mountain sheep, 33% of that for moose, and 30% of that for caribou. As noted already, some of the provincial objectives are no longer valid with 50,000 elk and 25,000 mountain sheep probably being more realistic. This would lower the zone contribution to the total to 50% for elk and 72% for mountain sheep.

Table 6. Northeast Zone Objectives for Elk, Mountain Sheep, Moose and Caribou.

Subunit	Elk	Mt. Sheep	Moose*	Caribou+
Deadwood	100	500	4,000	1,000
Kechika	10,000	6,000	16,000	500
Liard	400	100	10,000	500
Rabbit	100	900	6,000	1,000
Toad	200	1,300	4,000	500
Crest	-	500	2,000	250
Muskwa	12,000	6,000	20,000	1,000
Fort Nelson	100	100	9,000	100
Etsho	-	-	8,000	150
Trutch	400	100	7,000	-
Sikanni	1,700	2,500	14,000	2,000
	25,000	18,000	100,000	6,000

* Many of these units are, from a range standpoint, very productive for moose. In many cases, the numbers given here are less than the biological capability since it is unclear at this time whether public demand would exceed a standing crop of 100,000 moose in the area.

\+ Historic highs are estimated at about 10,000. It is felt that development may have reduced the potential to again reach that level.

Table 7 examines the contribution on a percentage basis that each of the subunits can make towards meeting the zonal objective. Table 8 takes these numbers, divides them by the

Table 7. Subunit Potential Percent Contribution to Meeting Zonal Objectives for Elk, Mountain Sheep, Moose and Caribou.

Subunit	Elk	Mt. Sheep	Moose	Caribou
Deadwood	1	3	4	17
Kechika	40	33	16	8
Liard	2	1	10	8
Rabbit	1	5	6	17
Toad	1	7	4	8
Crest	-	3	2	4
Muskwa	48	33	20	17
Fort Nelson	1	1	9	2
Etsho	-	-	8	2
Trutch	2	1	7	-
Sikanni	7	14	14	33

subunit land area and multiplies by 100000 in order to derive an area free rating which can be used in subunit priorization. The final priorization is somewhat arbitrary. Elk and mountain

sheep from this zone must be given a greater weighting than moose (the other first priority species of Table 4) due to

Table 8. Rating * of Subunit Potential Contribution to Meeting Zonal Objectives for Elk, Moose, Mountain Sheep, and Caribou.

Subunit	Elk	Mt. Sheep	Moose	Caribou
Deadwood	14	43	57	243
Kechika	267	220	107	53
Liard	16	8	80	64
Rabbit	12	62	75	212
Toad	12	87	50	100
Crest	-	50	33	70
Muskwa	343	236	143	121
Fort Nelson	7	7	62	14
Etsho	-	-	21	8
Trutch	29	14	100	-
Sikanni	108	215	215	508

* see text

their significance to meeting the provincial objectives. While moose and caribou are rated equally provincially, the smaller potential

Table 9. Weighted Rating * and Ranking of Subunit Potential Contribution to Meeting Zonal Objectives.

Subunit	Weighted Species Rating				Overall Rating	Rank+
	Elk	Mt. Sheep	Moose	Caribou		
Deadwood	14	43	29	61	147	3
Kechika	267	220	54	13	554	2
Liard	16	8	40	16	80	4
Rabbit	12	62	38	53	165	3
Toad	12	87	25	25	149	3
Crest	-	50	17	18	85	4
Muskwa	343	236	72	30	681	1
Fort Nelson	7	7	31	4	49	5
Etsho	-	-	21	2	23	5
Trutch	29	14	50	-	93	4
Sikanni	108	215	108	127	558	2

* see text

\+ grouped

for caribou dropped it one level zonally (Table 4). Elk and mountain sheep, therefore, will be weighted 1.00, moose -0.50, and caribou - 0.25. Table 9 takes the ratings of Table 8, weights them, and yields an overall zonal rating and priority rank. It can be seen that the Muskwa unit is the most important to meeting zonal objectives with the Kechika and Sikanni units the next most important. The Muskwa unit alone can provide 24% of the province's elk objective, 24% of the province's mountain sheep objective, 7% of the province's moose objective, and 5% of the province's caribou objective.

2. Purpose

It was highlighted in the first section that the Muskwa subunit was the first priority subunit to meet the zonal wildlife management objectives. It can however be seen that the present numbers of animals in that area are below the objectives. Unfortunately existing numbers of animals do not present the full picture. It will be seen in the Background section that the viability of the herds ranges from mediocre to poor.

Mountain sheep are in the worst position with major declines having occurred. Hunting restrictions have been minimal thus far, as numbers available for harvest are based upon individuals born 7 to 12 years ago when numbers were well above present levels. Even if the present trend is reversed immediately as a result of this and similar projects, a period of significant harvest restrictions can be expected during the lag time required to grow a huntable animal - not to mention rebuild ewe numbers. Each year's delay in mountain sheep management requires a minimum

of one year just to regain the loss. Thus there are two years lost for every year delay before any improvement is gained on present numbers.

The situation for elk is less urgent than that for mountain sheep but is far from desirable. A major thrust has been made to expand the elk herd within the zone. It has thus far been two pronged: 1) range expansion through controlled burning and 2) supplementary introductions (planned). Both of these procedures are dependent upon a vigorous (expanding) Muskwa herd: 1) elk will be reluctant to establish on new ranges if population pressure is lessening on traditional ranges through herd decline and 2) removal of individuals from the Muskwa to other sites will aggravate a situation of declining population. In addition a declining herd provides little in the way of surplus for hunting.

Moose problems are ameliorated by a lower level of demand at this time with no enhancement programs dependent on a vigorous

population nor extreme hunting pressure. However with the supply of moose declining and hunter demand increasing the situation is not satisfactory.

Caribou do not seem to be further declining but are present at only about one-third of past recorded levels for the unit with little available for hunting.

3. The Study Area.

A. General

The study area lies southwest of Fort Nelson, British Columbia (Figure 2), and encompasses portions of the Eastern System of the Canadian Cordillera and the Interior Plains (Holland, 1964). The physiographic zones involved are the Muskwa Ranges of the Rocky Mountains, the Rocky Mountain Foothills, a fringing cuesta, and the Fort Nelson Lowlands of the Alberta Plateau to the east. Extending from the Prophet River in the south, to the Toad River in the north, the area covers approximately 14,000 km^2.

B. The Rocky Mountain Zone

The Muskwa Ranges.

Characteristic of the Muskwa Ranges and the Rocky Mountain Foothills to the east, are the uneven glaciation, and extensive valleys eroded parallel to structural trends of faulting, or belts of easily eroded rocks. The result is a pronounced trellis pattern, with deeply eroded valleys such as the Prophet River, Muskwa River, Racing and Churchill Rivers, and others rising abruptly in steep relief from the Boreal White and Black

Spruce to the spruce-willow-birch and extensive alpine tundra biogeoclimatic zones (Krajina, 1965).

Within the study area the Muskwa Ranges are deeply eroded in Devonian and Permo-Carboniferous limestone which were largely covered during the Pleistocene by continental ice, to elevations between 1200 and 2400 m. Many areas have elevations higher than this, with peaks such as Mount Churchill rising to 3200 m. These are highly castellated quartzite and limestone ranges which, combined with the effects of the alpine and valley glaciation and lengthy valleys created by ice retreat, offer spectacular scenery and a diversity of wildlife habitats. In general, the Muskwa Ranges are underlain by sedimentary and metamorphic rocks ranging from Proterozoic to Cretaceous in age. Exposed formations are youngest in the foothills, with progressively older formations occurring to the west.

C. The Rocky Mountain Foothill Zone.

Within the Rocky Mountain Foothills, there are two subdivisions which run parallel to one another in a northwesterly

direction. The inner foothills abut against the Rocky Mountains on the west, and consist of closely folded fault zones of thick Paleozoic limestones. The inner foothills are more rugged than the outer foothills, and both are underlain by sedimentary rocks of various ages, arranged in northwesterly running ridges called fault thrusts.

The origins of the large west to east running valleys lie in the Rocky Mountains, and as mentioned above they continue through the Foothill Zone throughout the more erodible fault zones and softer shales. The floors of the valleys are deeply drift-filled, and range from 760 m to 910 m in elevation. The valleys are wide and are "U" shaped, with the north-south running ridges becoming increasingly subdued in elevation and relief from west to east. Elevations of the ridges average about 1500 m, with the vegetation of the valleys progressing from the Boreal White and Black Spruce Zone to the Spruce-Willow-Birch Zone, and the Alpine Tundra Zones (Krajina, 1964) with increasing elevation. The deeply incised valleys of Kluachesi Creek, Gathto Creek, Dead Dog Creek, Tuchodi River,

Falk Creek, and so on present optimal wildlife habitat in a variety of successional stages due to their aspects, elevation, soil developments, and climate. Reflecting the high wildlife values of the area an extensive history of the use of fire to encourage early successional vegetation is apparent throughout. Much of this dates back to very early times, however horse range improvements by an active Guide-Outfitting industry in the area have had a significant effect.

D. The Muskwa/Prophet Cuesta.

East of the Rocky Mountain Foothills between the Muskwa and Prophet Rivers, there is a distinct cuesta formed by the gentle folding of the Sikanni Sandstone Formation. The cuesta slopes gently east, to the Prophet River, with an abrupt scarp dropping from 1500 m to the Muskwa River valley, at about 750 m elevation on the west. Elevations range from 1500 m on the west to 600 m on the east. The southern edge of the cuesta has a scarp which drops steeply down to the Fort Nelson Lowlands. The vegatative characteristics are rather similar to the foothills to the west, and the many deeply incised valleys such as Tenaka Creek,

the Akue River, Seeds Creek and so on, offer diverse and productive wildlife habitats encompassing the Boreal White and Black Spruce, the Spruce-Willow-Birch, and the Alpine Tundra Biogeoclimatic Zones (Krajina, 1964). Fire history has been irregular in this area with only a few wildfires creating optimal successional stages for wildllife in recent years.

E. The Fort Nelson Lowlands.

This zone includes the Prophet River valley and the large poorly drained flats south of the cuesta, between the Prophet and Muskwa Rivers. The area is largely a black spruce-willow-birch association, with limited better drained areas supporting white spruce, lodgepole pine, or aspen depending on local fire history and soil conditions. Elevations are below 610 m., (Holland 1964).

F. Climate

Characteristic of the boreal forest are the long harsh winters and cool, moist summers. Precipitation averages about 45 cm and is variable, with 50% to 60% occurring during the summer months as rain. (Figure 3 and Tables 10, 11, and 12). This

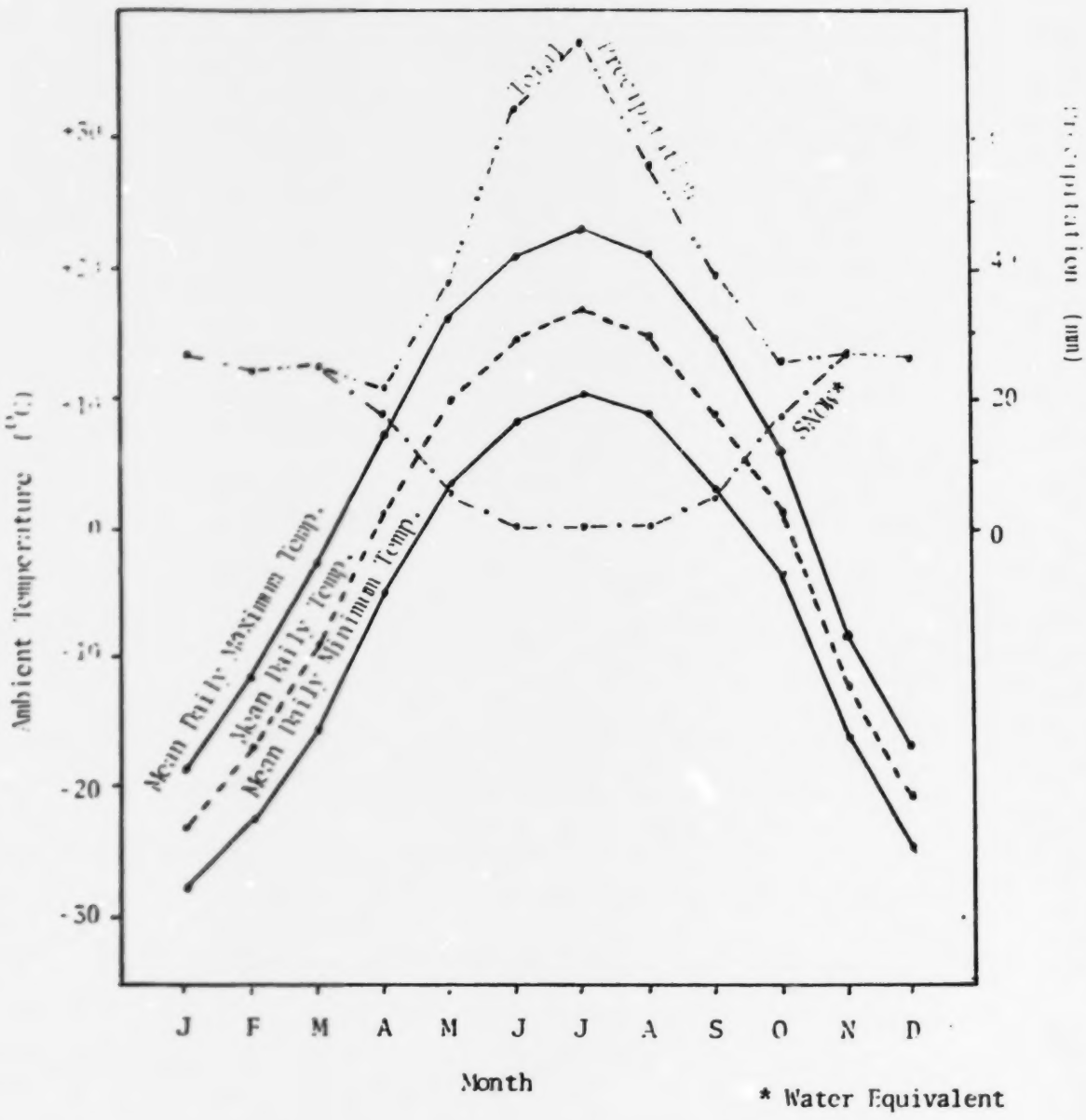


Figure 3 Climate diagram for Fort Nelson, B.C. (58°48' N; 122° 45' W). Based on 30 year mean values (1941 to 1970) (B.C. Dept. Agric., 1971).

...../

occurs due to cyclonic storms from the Gulf of Alaska which bring heavy short term showers. During the winter months weather is dominated by polar air masses centering over the Northwest Terrritories, and total snowfall averages about 192 cm., depending on elevation, slope and aspect.

Figure 3 presents a summary climate diagram for the area using the 30 year weather records from Fort Nelson. Weather data for the foothills and mountain portions of the study area are generally lacking, and are highly variable.

Temperature inversions and strong, frequent chinook winds make the foothills and mountains more attractive to wildlife due to snow removal and energy advantages. There is also a significant snow shadow effect from the high Muskwa Ranges to the west. Temperature extremes range from $-59^{o}C$ during January to $+33^{o}C$ in June, and mean daily temperatures range from $-9^{o}C$ to $+3^{o}C$.

Solar radiation plays an important role in these harsh climates and many species such as sheep and elk utilize areas

maximizing sunlight during the winter. Sunlight duration for the period October 15th to June 20th ranges from 6 to 20 hours per day.

Table 10. Mean Total Precipitation Summary for the Months January to June from Fort Nelson and Muncho Lake.

Location	January	February	March	April	May	June	Number of Years of Record
Fort Nelson	26.4*	24.4	24.9	21.6	37.6	64.3	30
Muncho Lake	40.8	35.7	17.5	8.2	42.2	50.0	9

* mm

Table 11. Snow Depths at Fort Nelson and Summit Lake for the Months January to June

Location	January	February	March	April	May	June	Number of Years of Record
Fort Nelson	32.5*	46.8	52.2	49.5	3.8	0.0	15
Summit Lake	N/A	39.1	45.8	48.6	15.4	0.0	1

* cm

Table 12. Mean Temperatures from Weather Recording Stations at Fort Nelson and Muncho Lake from January to June.

Location	January	February	March	April	May	June	Number of Years of Record
Fort Nelson	-23.2	-17.0	-9.2	+1.2	+9.6	+14.5	30
Muncho Lake	-13.4	-18.0	-2.7	-0.8	+6.2	+11.4	4

4. Background

A. Present Population Status and Problem Identification

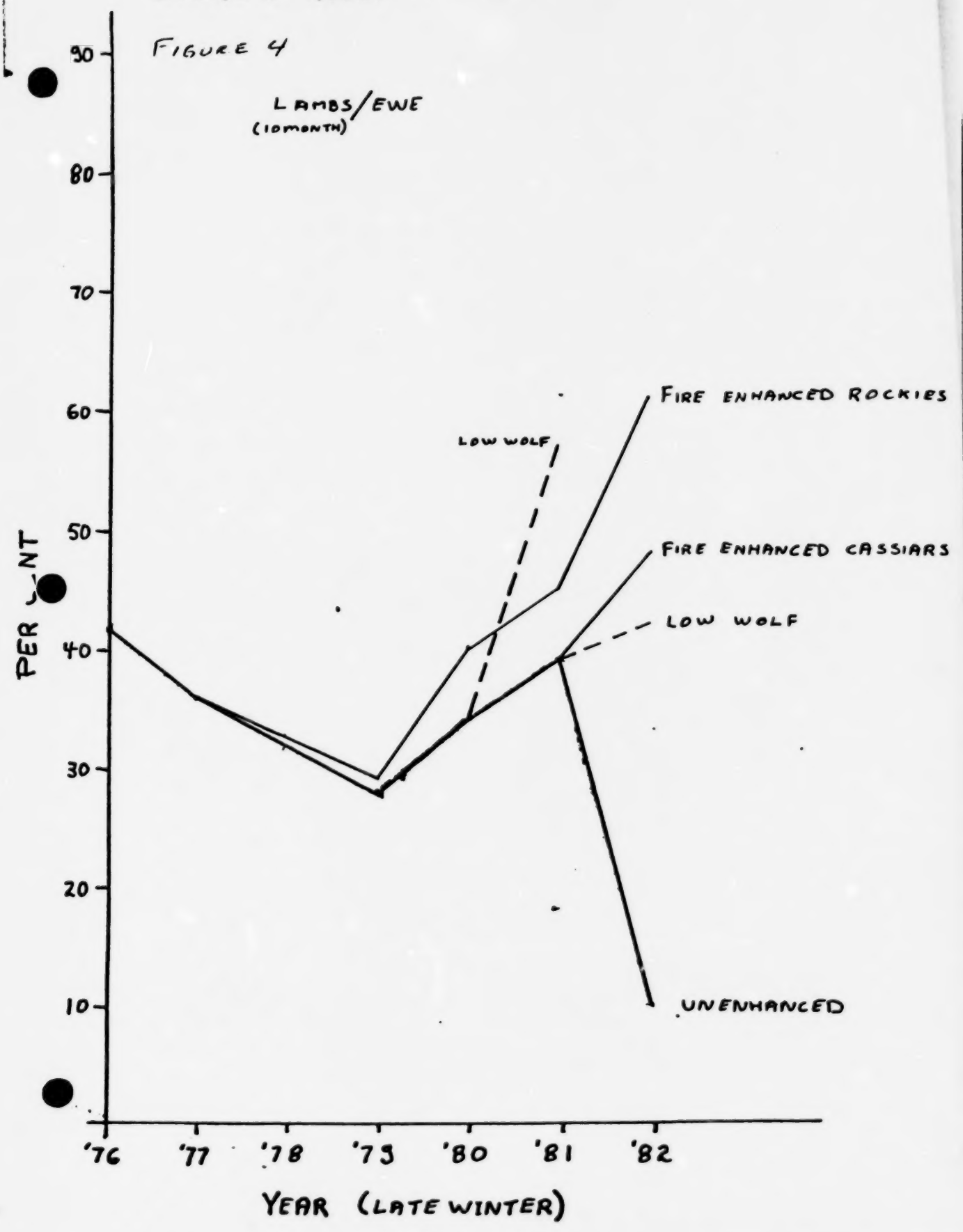
i) Mountain Sheep.

The Muskwa area presently contains about 3000 mountain sheep (Table 5). As with other mountain sheep areas in the northeast (Elliott and Webster, 1982 a), a substantial decline in population size has occurred in the last 5 to 10 years. Indeed the decline is so severe that it is difficult with scanty inventory data to maintain a monitoring of the herds. Thus the estimate of 3000 is probably a maximum figure for the area - there may be as few as 1500 mountain sheep now present.

Figures 4 and 5 provide insight into the collapse of the mountain sheep population. These figures show population recruitment (10 and 22 month) data for mountain sheep for north eastern British Columbia for the period 1976 to 1982 (from these

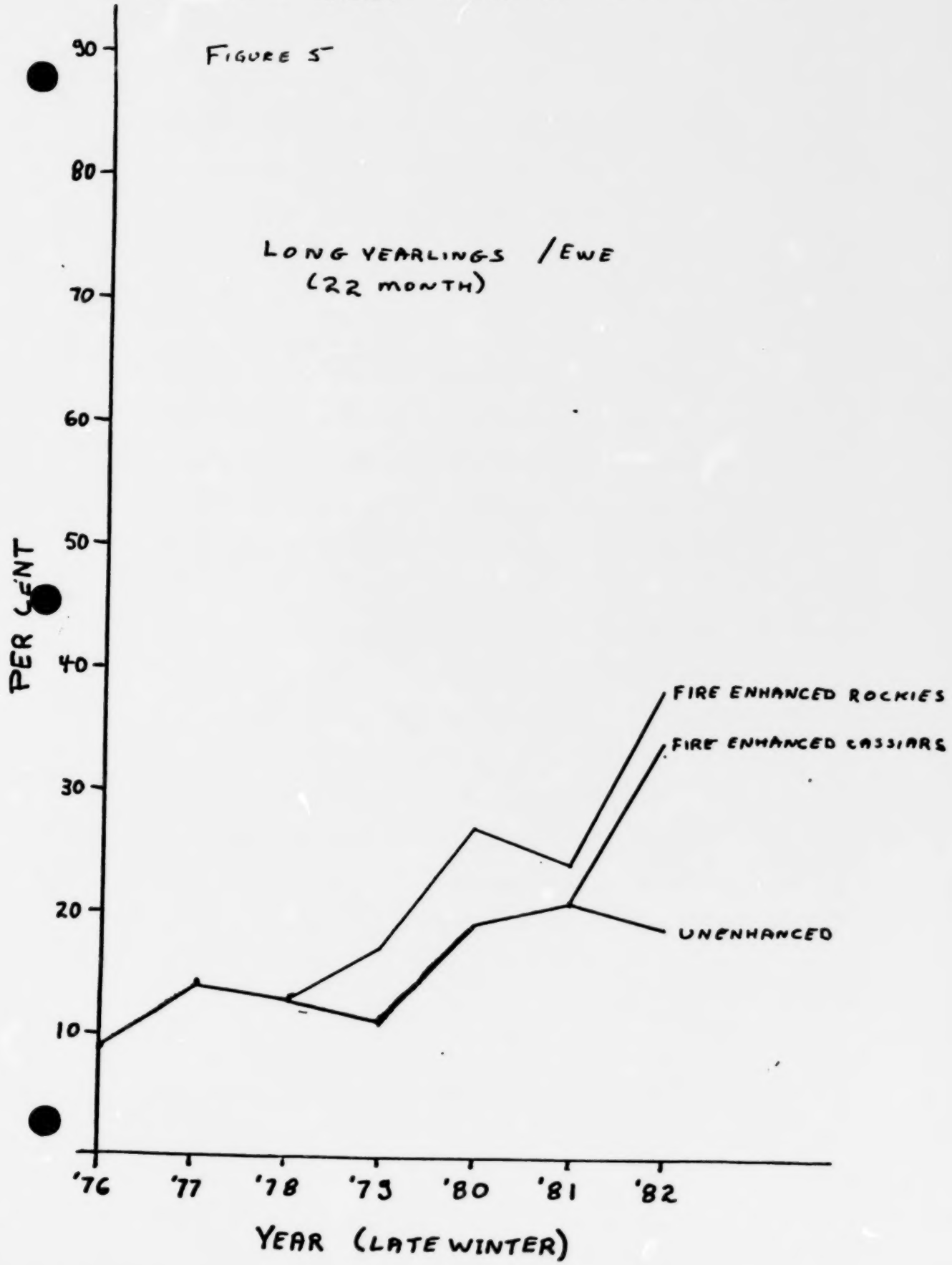
STONE'S SHEEP LAMB RATIOS

FIGURE 4



STONE'S SHEEP LONG YEARLING RATIOS

FIGURE 5



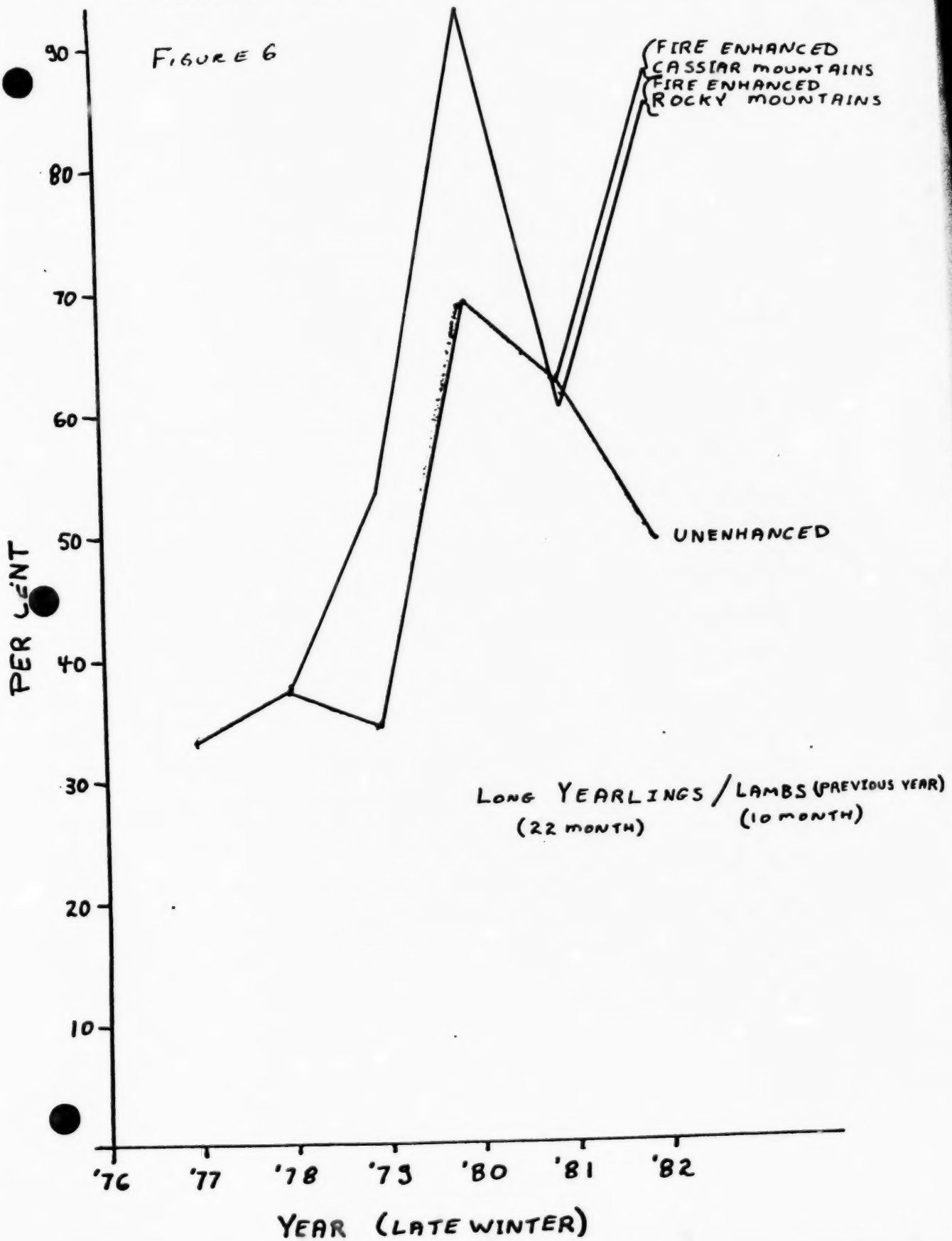
data one can calculate second year survival (Figure 6). In addition they show the population recruitment effect of controlled burning for the enhancement of significant amounts of new range both for the northern Rockies' sites since 1979 and the Cassiars' sites for 1982.

It is important to consider the significance of the identified unenhanced recruitments. To do this it is necessary to know the adult ewe pregnancy rate and the survival rate beyond two years of age. Of these two, the latter is the more significant to management.

No pregnancy rates are available for Stone's sheep. A wide range of rates have been reported for Dall's (Hoefs and Cowan, 1979; Heimer, 1978; Nichols, unpubl.). These rates fall between 41 and 100% for adult ewes. One July count for Stone's sheep (Elliott, unpubl.) showed 47 lambs per 100 ewes over two years (sample of 521 ewes). Hoefs and Cowan (1979) found 15 to 20% of the Dall's lambs died in the first month of life. Bunnell (1980) identified a higher rate. Given the

STONE'S SHEEP LONG YEARLING TO LAMB RATIOS

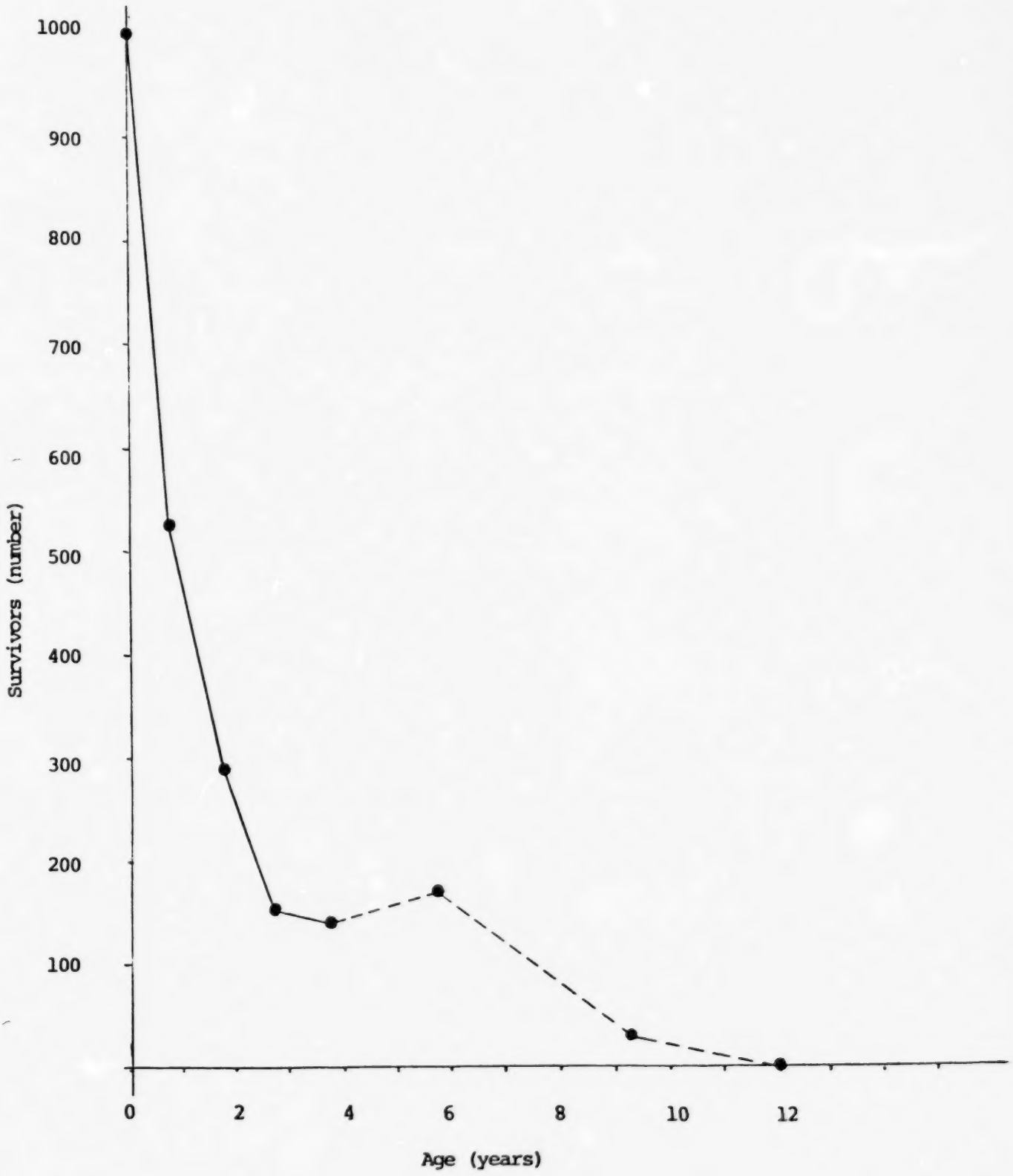
FIGURE 6



generally higher juvenile mortality of Stone's and excluding 26 month ewes, it appears that pregnancy rates may be in the order of 75% for Stone's sheep.

Thus far, no direct data exist for adult ewe mortality. In 1981 (late winter) a sample of 988 Stone's rams from a hunted area were classified as to age during an aerial survey. Animals under two years were assumed to be 50% male. Older animals were categorized on the basis of horn growth as: 34 months, 46 months, 58-82 months and 94-142 months. The results of this survey are shown in Figure 7 and assume a 75% pregnancy rate for adult ewes. As this age structure is based on data from one point in time, it does not give a true picture of the mortality/survivorship rate. The number of three year olds can however be compared to the number of two year olds the previous year (Figure 5) and it can be calculated for 1980-1981 that third year ram mortality was 42%. Beyond this age one cannot calculate true mortality rates and regardless, male and female mortalities would not be expected to be similar for older animals. Hoefs and Cowan (1979) found an annual adult ewe mortality at Kluane of 20% which may or may not apply to Stone's.

Figure 7. Structure of Stone's Ram Population - 1981.
(Hunted)



Taking the data from Figure 5, it can be calculated that the average 22 month female recruitment (assuming 50% female long yearlings) is 7% for the period 1976 to 1982. Utilizing the ram third year mortality this gives just over 4% recruitment at three years. If indeed the 20% adult mortality figure applies, the ewe herd can be expected to have declined at 16% per year on average over the last six years - a decline of about two-thirds.

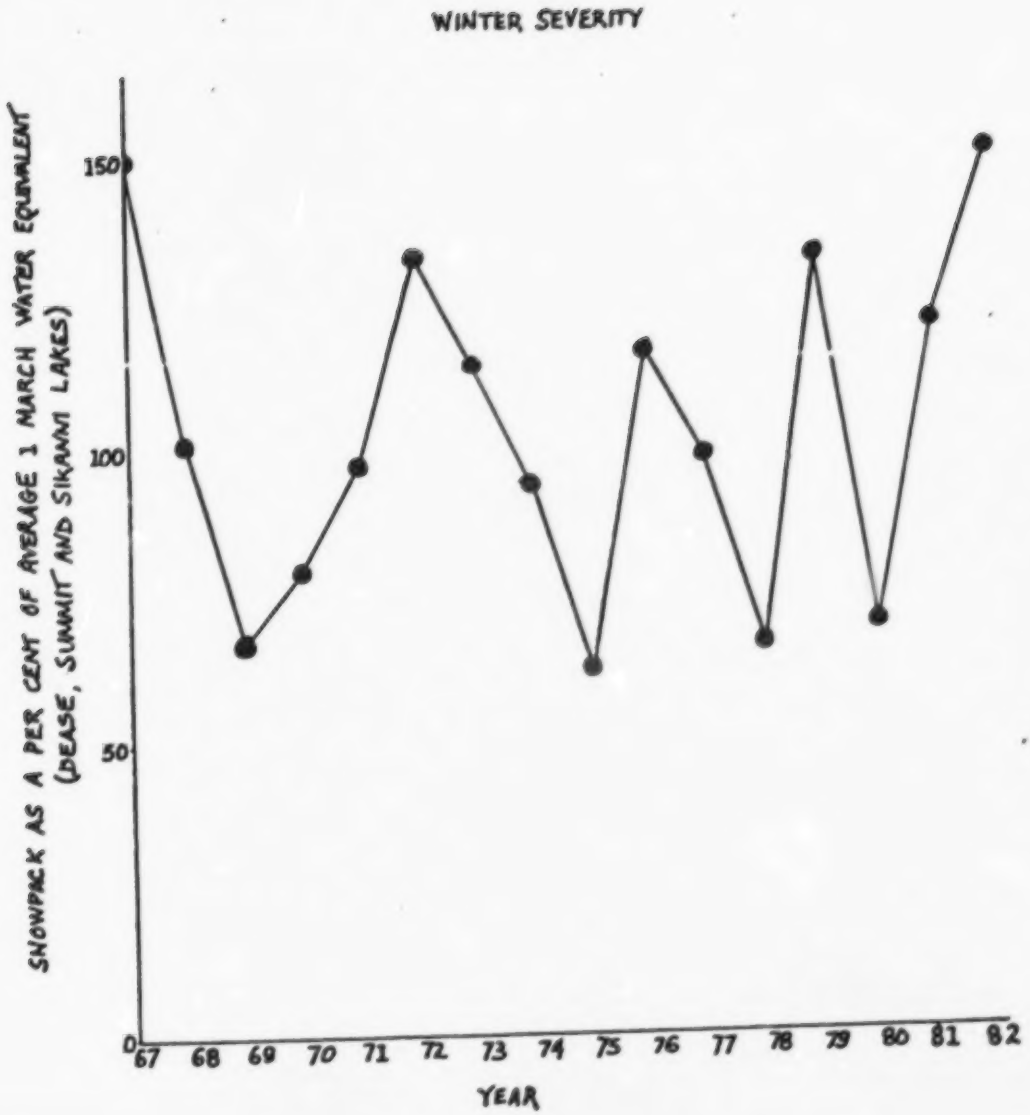
R. Kjos (pers. comm.) counted 522 mountain sheep in a portion of the Stone Range of the Muskea in ca 1975. That same area now contains less than 200 mountain sheep. Other areas where estimates are available for two points in time (Elliott and Webster, 1982b) show a similar magnitude of change. This magnitude reinforces the validity of the recruitment mortality calculations.

Thus far then we have defined the problem - Stone's sheep are declining rather rapidly. What is causing this decline and what can be done to reverse it?

Figure 8 presents an index of winter severity for north-eastern British Columbia. A comparison of this index with first and second year survival (Figures 4 and 6) shows that second year survival is not correlated ($r = -0.0397$) while first year survival is ($r = 0.8056$). It appears then that the effect of a severe winter (as defined by the index) is to interact with a direct mortality agent which shows little selective difference between second year animals and adult ewes but which does select against first year individuals.

The range enhancement program utilizing controlled burning does appear to alleviate the situation with improvement in both first year (Figure 4) and second year (Figure 6) survival. (The trend to increasing survival in the fire enhanced Rockies is considered to correspond with an increasing proportion of the herd utilizing the enhanced ranges). Sheep population response to the fire enhanced ranges has shown up to 16% female recruitment (22 month) of sheep on unenhanced ranges. The range enhancement through burning thus yields a substantial improvement in population status. The effect upon third and subsequent year survival/

FIGURE 8


WINTER SEVERITY
SNOWPACK AS A PER CENT OF AVERAGE 1 MARCH WATER EQUIVALENT
(DEASE, SUMMIT AND SIKANNI LAKES)
150
100
50
0
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
YEAR

mortality is however, unknown at this stage, and is a priority item for identification. Were it unchanged by the range enhancement, the sheep population would still be declining although much less severely than in the unenhanced state.

There are however several items of data which implicate a significant role to predation in mountain sheep population status. Firstly, it must be noted that the decline of sheep in the Muskwa subunit and elsewhere in northeastern British Columbia occurred during a period of overall more or less average winters (Figure 8), with no hunting season for ewes, no indications of disease, but high numbers of wolves (Elliott and Webster, 1982 b). Further, although they do not highlight predation, Hoefs and Cowan (1979) found that nine of twenty-four (38%) adult sheep natural mortalities in Kluane resulted from predators. Thirteen (54%) resulted from unknown causes.

Two areas (Major Mountain in 1980-1981 and Ewe Range in 1981-1982) not enhanced by fire have shown significant one year

declines in wolf numbers (Elliott and Webster, 1982b). In both cases lamb survival has been markedly increased. Second year survival relative to adult ewe survival showed little change.

R. Vince (pers. comm.) indicates that he has seen frequently over the years, a marked switching of wolves to sheep predation from moose and elk during heavy autumn snowfalls, with lambs taking the brunt of the predation. Deep snow appears to interact with predation in two ways. Firstly, it hinders running by the sheep more so than it does wolves, and secondly, it often necessitates the sheep moving further from predator escape terrain to feed. In snow away from escape terrain it seems to be relatively straightforward for wolves to capture sheep. For example, a pack of thirteen wolves was encountered on the south knob of Rapid Mountain in early March. This pack had just killed three sheep (one ewe, one yearling and one unidentified) and human disturbance may have stopped further hunting.

Twenty-two sheep remained. This pack had been encountered on the same knob two days previously at which time they were feeding on two other sheep (one young ram and one unidentified). One month later there were 7 sheep on the south knob plus an additional 8 sheep on the north knob. C. Widrig (pers. comm.) saw about 75 sheep on the mountain in November, in April there were 34 sheep in total. The isolation of this mountain and deep winter snows make emigration during this period improbable.

Given the ease of mountain sheep capture by wolves, the manner in which range enhancement through burning improves survival is not clear. Does it operate through allowing a higher plane of nutrition or through reducing the need to travel far from escape terrain and thus lowering exposure to predation? Likely both are involved and this aspect is being investigated (Elliott and Webster, 1982 b).

ii) Elk

The status of elk in the Gathto-Tuchodi area of the Muskwa subunit has been discussed by Elliott and Webster (1982c). The Gathto-Tuchodi area is felt to have seen an expanding elk population until the mid-seventies at which time wolf numbers increased from few to many and the elk population began to stagnate (Peck, pers. comm.). Surveys in February and March, 1982 identified the Gathto-Tuchodi area as having the highest recorded wolf density for northern British Columbia: 39 square kilometers (15 square miles) per wolf. Further, the female segment of the elk herd was found to have only 12% recruitment to 22 months. Data of Peck (unpubl.) suggest this level results from variable first year mortality and fairly constant second year mortality. Carbyn (1974) found for Jasper that the adult natural mortality rate was 14% which if applicable to Tuchodi-Gathto would yield a 2% annual decline in the absence of hunting.

Elk in the Gathto-Tuchodi area are three times as abundant as moose yet of 36 wolf kills found by Peck (pers. comm.), wolf-

killed elk were 8 times more numerous than wolf-killed moose. This indicates wolves have a 2.7:1 preference for elk. Sizeable wolf densities are maintainted by a multi-based prey systems with disproportionate impacts on prey such as elk.

Evidence from other areas suggest a high effect from predation upon elk. Carbyn (1974) compared elk mortality in Jasper (some wolves, adequate range) with Elk Island (no wolves, overutilized range) and found elk mortality from birth to 18 months of life was 50% greater in Jasper than in Elk Island. M. Schlegel (pers. comm.) demonstrated a marked recruitment increase for elk following a program of black bear reduction on an Idaho elk range.

iii) Moose

The Muskwa area presently contains upwards of 12,000 moose (Table 5). G. Vince and R. Peck (pers. comms.), however, indicate numbers are substantially down from their levels of ten years ago. Surveys in March of 1982 showed juvenile recruitment averaging about 11%. Natural mortality for northern British Columbia appears to be between 13 and 20% with the result that the Muskwa moose herds are declining at 2 to 9% per year exclusive of hunting loss.

Elliott and Webster (1982 b) present data relating wolf numbers to moose recruitment (10 month) for several sites and years. They found (Figure 9) that 55% of the total variation in moose recruitment was explicable by wolf densities. A further approximately 18% of the total variation was explicable on the basis of a prey swamping effect on predation by higher densities of prey. The data of Figure 9 suggest that at wolf densities exceeding 1 to 32-68 square miles, there is in general no surplus of moose available for population increase. The Muskwa area was found to have one wolf per 25 square miles.

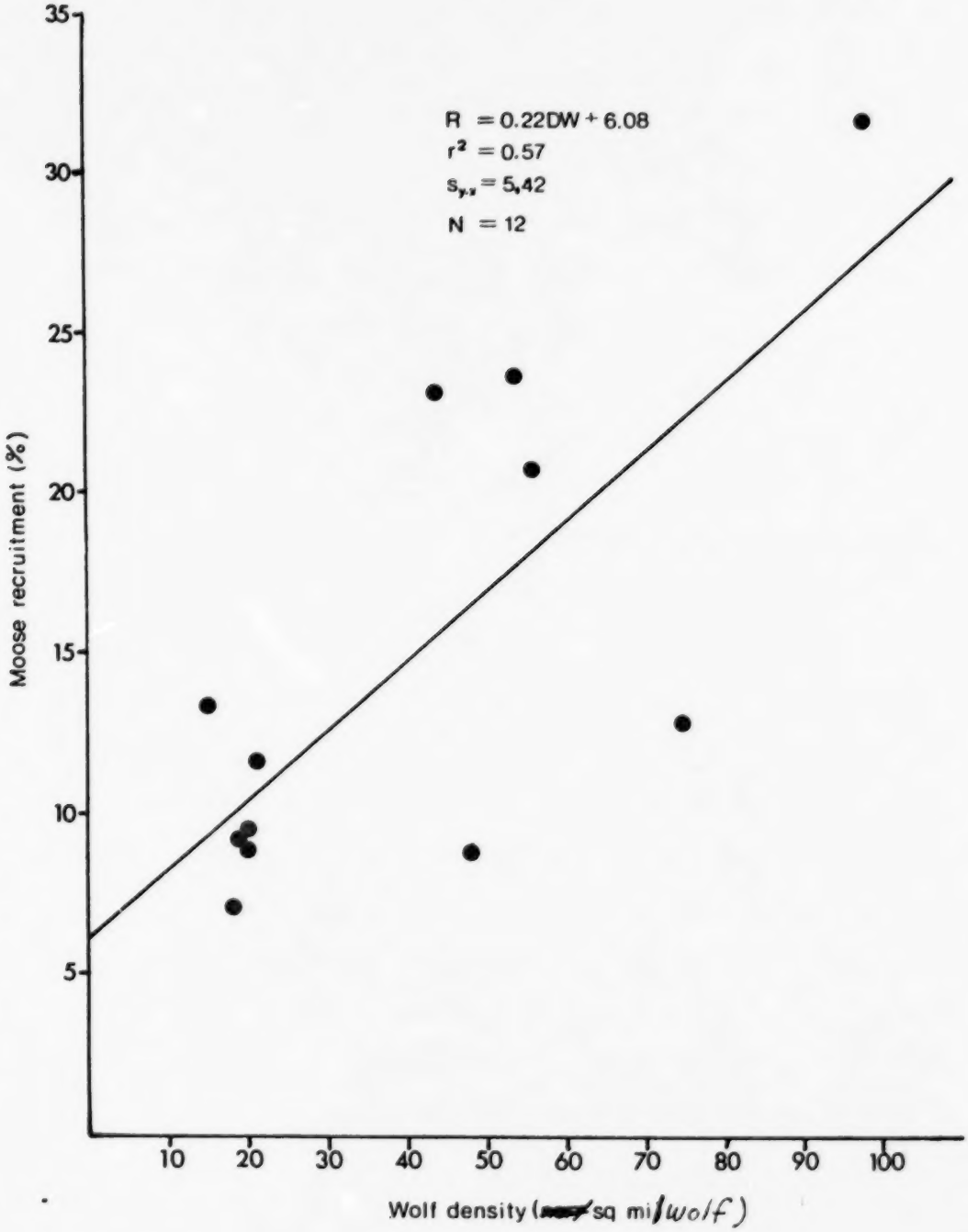


Fig. 9. Late winter moose recruitment relative to wolf density.

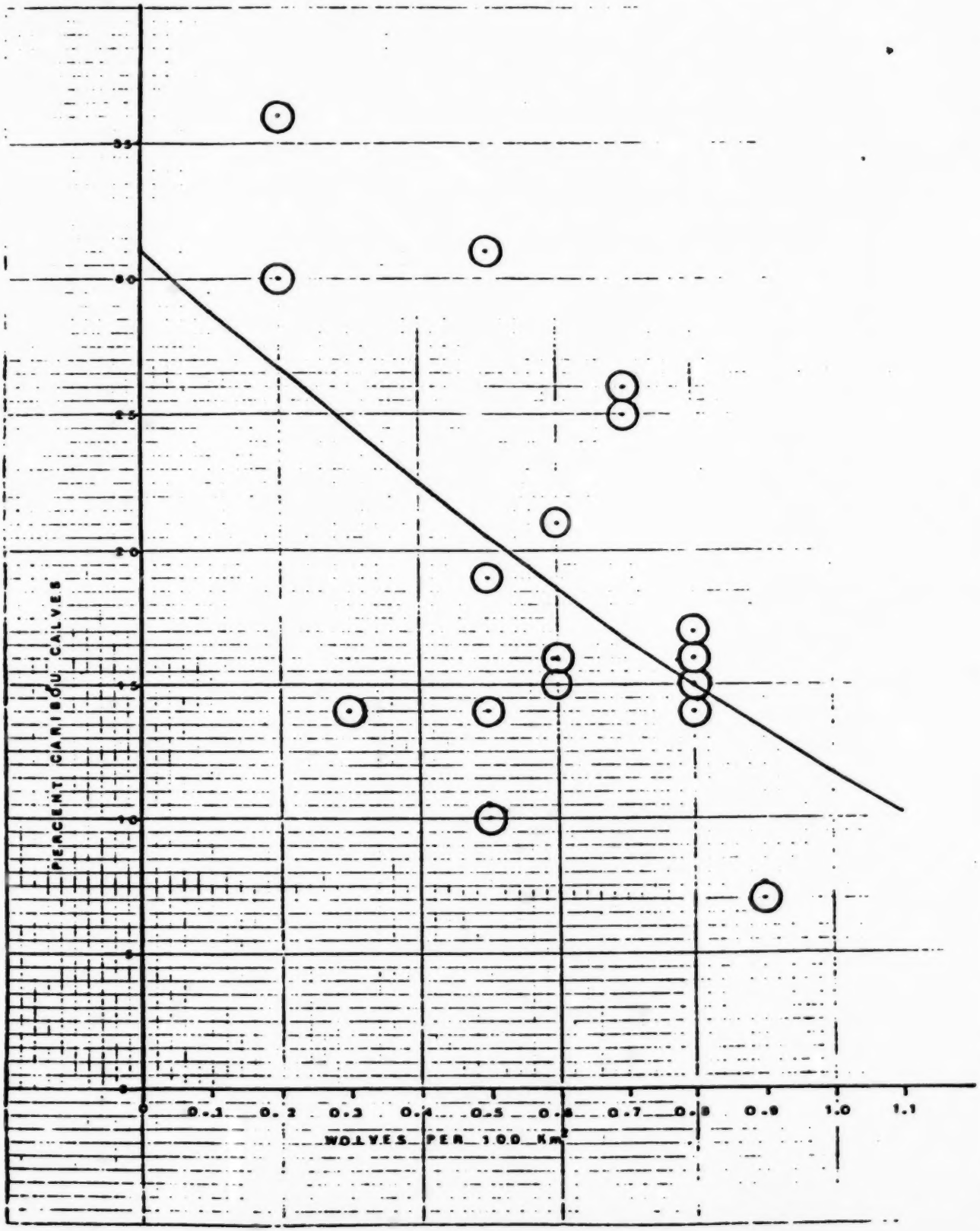
iv) Caribou

It is estimated the Muskwa area presently contains 500 caribou (Table 5). This is a substantial decline from numbers present in the late 1960's. Indeed R. Kjos (pers. comm.) counted approximately 1,100 animals in only a small portion (about 15%) of the Muskwa in 1970.

The Canada Land Inventory counted just over 150 caribou on the hills north of the Prophet River in January, 1969, an area which today is almost devoid of caribou.

The results of an extensive examination of the relation between caribou recruitment and wolf numbers have been reported by Wildlife Management Section (1983). That study found (Figure 10) that wolf density accounted for 38% of the variation in caribou calf recruitment over a wide area of northern British Columbia. A further approximately 8% of the total recruitment variation was identifiable as resulting from a prey swamping effect upon predation by higher biomasses of prey. A more detailed investigation of the wolf-caribou interaction (Elliott, 1982b) followed one caribou herd through

FIGURE 10 CARIBOU RECRUITMENT AND WOLF NUMBERS



four years and was able to reduce much of the random variability (subsampling, weather, vegetation, prey biomass, ...) of the previous study. This study found that 97% of the variation in caribou calf summer survival was accounted for by wolf numbers.

B) Supply and Demand

Non-hunting tourism use of wildlife is an important facet in the northeast of British Columbia. Unfortunately, usable statistics are nonexistent. It seems axiomatic that this type of use will lend to increase in proportion to animal abundance.

Statiistics related to hunting use of wildlife are more available Supply and demand are not independent variables. The non-essential (to survival) nature of hunting appears to result in measured demand changing in response to supply. This is illustrated in Figure 11 which compares the number of caribou hunters (demand) in the Peace-Liard area to the percent success of caribou hunters (supply). The two are closely correlated ($r = 0.7939$) with this measure of caribou demand (Y) dependent upon this measure of caribou supply (X) by the following:

$Y = 62.36 x - 447.6.$

It is of course axiomatic that real demand does not decline in response to reduced supply and that participation much underestimates demand. (Indeed during the period of caribou decline illustrated in Figure 11, overall human population and hunter numbers increased). It follows then that as for nonhunting use, increasing supply will increase particupation. Total sales of general hunting licences is probably close to a true resident demand for animals on the table with most of these purchasers wanting a minimum of one big game animal.

G-5D SQUARE 10 X 10 TO THE INCH
GRAPHIC CONTROLS
MADE IN CANADA

Figure 1

Peace/Liard Subregional Caribou Harvest by BC Resident Hunters from 1967 to 1981
Hunter Success versus the Number of Caribou Hunters

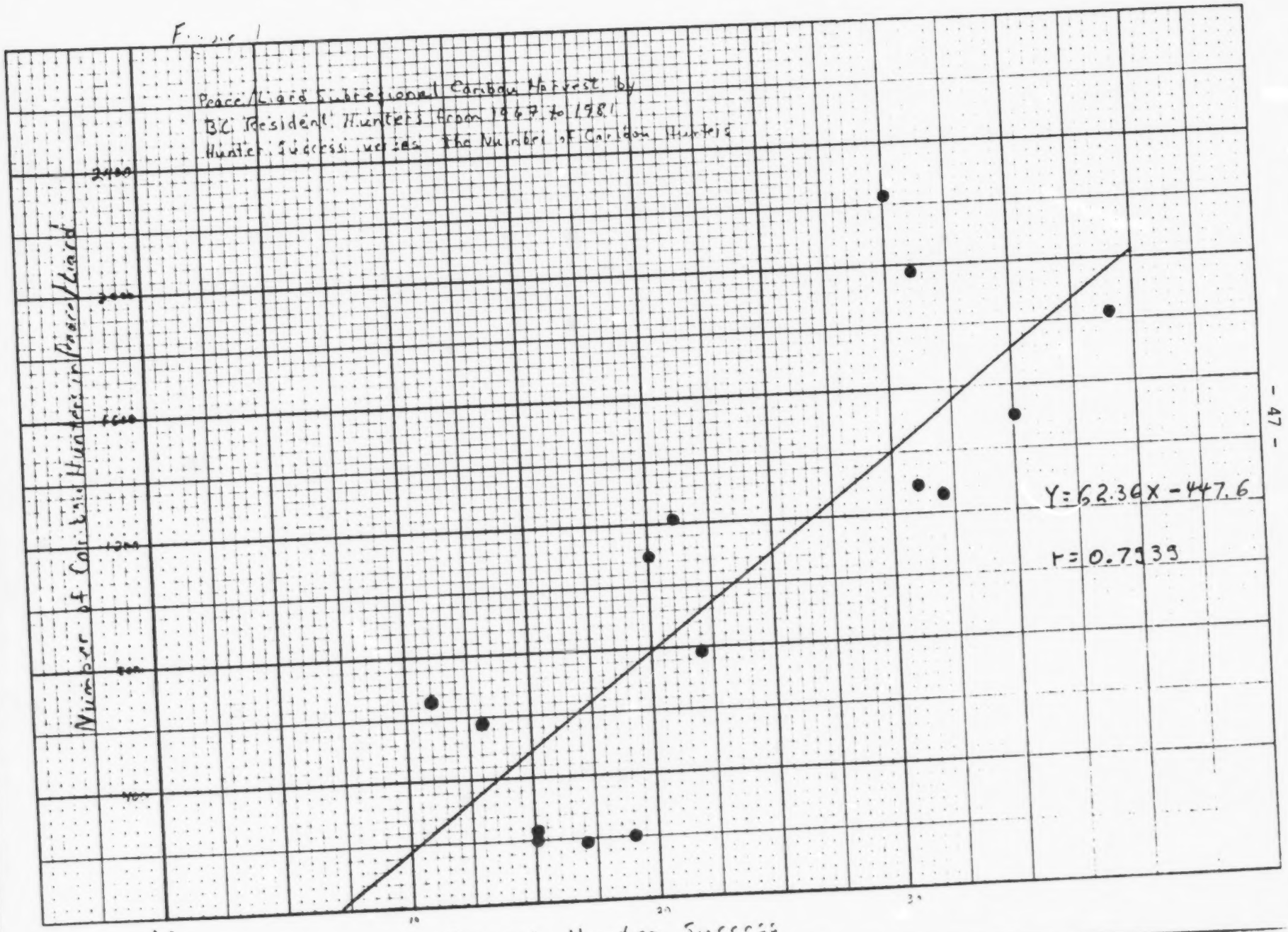


Table 13 summarizes total hunting licence sales for the period 1976 to 1981 during which fees have been stable. During that six year period there has been a steady increase in participation with a six year increase of 25%. Further it can be seen from a comparison with Table 2 that if the provincial objectives (which include the zonal objectives) were met, it would only be possible to provide one big game animal per two

Table 13. General Hunting Licence Sales to British Columbia Resident Hunters.

Year	Number of Licences Sold
1976	139,489
1977	144, 447
1978	155,605
1979	163,088
1980	167,879
1981	174,088

hunters. This would assume no animals available to non-resident hunters which is counter to Ministry policy. It would seem, then, that demand is not a justification for delaying achievement of provincial and zonal objectives but indeed is a reason for the need to progress towards them.

Table 14 looks at a different measure of demand. That table shows the demand for 1982 limited entry hunts in British Columbia for the four species under consideration. It can be seen that the demand supply ratio is much the highest for mountain sheep; however elk, moose and caribou are all well above 1.0.

Table 14. Demand/Supply Ratios Determined from 1982 Limited Entry Hunting.

Species	Number of Permits Available	Number of Applicants	Demand/Supply
mountain sheep	165	1,666	10.1
elk	3,849	12,765	3.3
moose	4,578	14,100	3.1
caribou	89	406	4.6

It follows (from the Background Section) that where natural mortality exceeds recruitment, the supply for public consumption is minimal or non-existent. The alternative is to hasten population declines as occurred for caribou in the early seventies.

5. Approach

It was noted in the Background section that low recruitment was coupled with apparent population decline - zonally and for the Muskwa unit. Further, low recruitment appeared in general to be correlated with high wolf numbers. Relative increases in food supplies, either through population declines or range enhancement, are not reversing the decline. Hunting is much curtailed with no female seasons for the four ungulates discussed. While sex ratios are skewed, they remain within limits found elsewhere to not restrict conception.

It is proposed to continue the elk range expansion program and expand the mountain sheep range enhancement program. It is further proposed to initiate a five year wolf management (reduction) program (reviewed after three years). The benefits foreseen by the program are simple: an advancement towards the objectives of Tables 2 and 6 with an improvement in the supply/demand ratio.

All of the procedures proposed have been utilized in the zone and found effective. The reduction of wolves remains somewhat

controversial although more than half of the public of the Province agree that this tool is essential to ungulate management (Self, 1982). If wolf management were to prove of limited value to enhancing the ungulates, the only environmental consequence would be a needless lowering of wolf numbers during the initial control period (three years) and a further depression for only two to three years while the population recovered.

Monitoring of ungulate response is of paramount importance to the project. From cost considerations, recruitment will be used as the key indicator of ungulate population response. Seven years of recruitment data now exist for mountain sheep, three years for elk, and one for moose. Some historical recruitment data also exists for caribou (Bergerud, 1978). Use of recruitment data requires knowledge of adult mortality and its response to management. This aspect is being investigated in the Kechika area for mountain sheep, should develop from the Muskwa program for elk, is being explored by the Fish and Wildlife Branch (Research Section, Victoria) for moose and is known for caribou.

Mountain sheep recruitments would be obtained for 9 and 21 months, elk recruitments for 9 months plus 21 months for males, moose recruitments at 9 months plus 16 months for males, and caribou recruitments for 6-9 months. Elk must be reinventoried in 1988. In addition wolves will be inventoried and reduced (estimated eighty per cent).

Four options exist for wolf reduction: aerial shooting, poisoning under existing guidelines, poisoning under relaxed guidelines, and poisoning under relaxed guidelines with some aerial shooting subsequent to poisoning. Table 15 presents the costing for each option.

Table 15. Muskwa Project Annual Costs

Activity	Option 1	Option 2	Option 3	Option 4
Mountain sheep, recruitment	5,000	5,000	5,000	5,000
elk, recruitment	4,500	4,500	4,500	4,500
moose, recruitment	4,500	4,500	4,500	4,500
caribou, recruitment	5,000	5,000	5,000	5,000
wolf, inventory Prereduction	5,000	20,000	20,000	20,000
wolf, inventory post reduction		20,000	20,000	20,000
wolf reduction *	24,000	30,000	5,000	8,000
Total	48,000	89,000	64,000	67,000

Option 1: aerial shooting

Option 2: poisoning under existing guidelines

Option 3: poisoning under relaxed guidelines

Option 4: poisoning under relaxed guidelines, some aerial shooting subsequent to poisoning.

* Assumes 1 wolf per 25 square miles.

The relaxed guideline poisoning assumes bait placement from the air with no bait recovery. This option would be slightly less costly (10%) than the shooting option if one were satisfied with only a post-treatment wolf inventory. In view of increased effectiveness this latter option could be combined with some post poisoning shooting. Given public sentiment against poisoning, inclusion of a pre-reduction wolf inventory, greater effectiveness, and minor cost difference; the shooting only option may be the more practical. The cost saving associated with poisoning can only be realized when monitoring is not essential. It may be that future projects need not be monitored so closely as proposed here.

Considerable interaction with Peace-Liard individuals and groups has occurred and will continue relative to this program. Acceptance of the need for the program and interest in pursuing it appears virtually unanimous within the Peace-Liard area.

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